Fuel Cycle and System Considerations

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Overview

- ***System definition approach***
- ***Generic fuel cycle options***
- ***Fuel cycle specification***
- ***Symbiotic fuel cycle options***

System Definition Approach

- ***Evaluations required specification of entire system***
  - ***Reactor***
  - ***Energy conversion system***
  - ***Fuel cycle front and back end***

- ***Choice of fuel cycle for each system based in part on FCCG studies***
  - ***Achievable gains toward SU goals with different system options***
  - ***Potential for fuel cycle symbiosis***
    - ***Different reactors may fulfill specific actinide management functions***

Generic Fuel Cycle Options

REACTOR			FUEL CYCLE			
			Once Through	Partial Fissile Recycle	Full Fissile Recycle	Full Actinide Recycle
Thermal	Water	IPSR	U, Th	U, Th	Th	Th
		SBWR	U, Th	U, Th	Th	Th
		CANDU-NG	U, Th	U, Th	Th	Th
		SCWR-T	U, Th	U, Th	Th	Th
	Gas	PBR	U, Th	U, Th	Th	Th
		PMR	U, Th	U, Th	Th	Th
		VHTR	U, Th	U, Th	Th	Th
	NC	AHTR	U, Th	U, Th	Th	Th
		MSR			U, Th	U, Th
		VCR			U	U
Epithermal/ Fast	Water	HC-BWR			U, Th	U, Th
		SCWR-F			U, Th	U, Th
Fast	Gas	GFR			U, Th	U, Th
	LM	Na/A			U, Th	U, Th
		Na/B			U, Th	U, Th
		Pb/C-US			U, Th	U, Th
		Pb/C-RF			U, Th	U, Th
		Pb/D			U, Th	U, Th

Fuel Cycle Specification

- ***Once-through cycle** (U fertile) adopted for thermal reactors with solid fuel (water, gas, AHTR)*
  - *Prevalent deployment configuration (~90% of capacity if deployed alongside Pu-recycle variant)*
  - *Limited fissile recycle (established for water reactors) achieves*
    - » *Modest gain in fuel utilization*
    - » *Significant reduction in HLW mass (U removal)*
    - » *Limited radio-toxicity reduction benefit*
  - *Full fissile (Pu) and full actinide recycle less attractive than in fast-spectrum or fluid fueled systems*
    - » *Technical challenges and performance penalties result from buildup of higher Pu isotopes and minor actinides in thermal spectrum*

Fuel Cycle Specification, cont'd

- ***<u>Full fissile or full actinide recycle</u> (Th fertile) adopted for closed-cycle GCR***
  - ***Closed Th cycle is also an option for other thermal reactors***
  - ***Waste management benefits are greater for full actinide recycle, but technical viability and performance potential are not established***
  - ***Resource extension benefits of closed Th cycle are greatest for high conversion-ratio cores (e.g., GCR, HC-ABWR, and HWR)***

Fuel Cycle Specification, cont'd

- ***<u>Full actinide recycle</u> adopted for:***
  - ***a) Fast water, gas, and LM reactor systems (U fertile)***
  - ***b) Fluid fueled reactor systems (U for VCR, Th for MSR)***

  - ***Initial fissile inventory extracted from LWR/ALWR SNF***
  - ***Full actinide recycle yields significant reduction of long-term waste toxicity and decay heat***
  - ***Symbiotic with thermal reactors whose irradiated fuel can be efficiently reprocessed***
  - ***Actinide-burning fast spectrum systems provide transition to breeding should this be required in the future***

Symbiotic Fuel Cycle Options

- ***Simultaneously advance Gen IV waste management and economic goals***

{ALWR, CANDU-NG, SBWR, IPSR, SCWR-T}

{PBR, PMR, VHTR} **+** { ***Na-Oxide LMR*** / ***Na-Metal LMR*** / ***Pb-Bi LMR*** / ***SCWR-F*** / ***GFR*** / ***MSR*** / ***VCR*** }

  - ***Technology for reprocessing GCR coated-particle fuel is not well established***

- ***Extend resources while retaining thermal reactors as part of the energy mix and limiting waste disposal challenges***

{Na LMR} **+** ***{VHTR, AHTR, MSR, HC-ABWR}***